SAFETY CONTROL AND IGNITION SYSTEM 
FOR FUEL BURNERS

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6 Claims. (Cl. 158—117.1)

1 This Invention relates to control systems for fuel burning apparatus and, more particularly, to electrically operated safety control and ignition systems therefor.

In the copending application of Charles K. Strobel, Serial No. 717,183 filed December 19, 1946, owned by the same assignee, now Pat. No. 2,482,549, granted October 25, 1949, there is disclosed a control system utilizing an electronic control device in conjunction with thermal resistance means for performing the controlling operation. In this copending application the input circuit of the electron tube is connected as the detector branch of an electrical bridge of which the thermal resistance means forms a branch or branches. As pointed out in the copending application, such an arrangement makes use of the desirable control characteristics of the thermal resistance means for varying the output energy of the electron tube in accordance with temperature conditions.

An object of the present invention is to utilize the output energy of an electronic device for direct operation of a fuel control means.

Another object of the invention is to facilitate the use of standard commercial types of fuel control means in the control system.

Another object of the invention is to simplify the circuit arrangements and reduce the number of component parts required to perform the controlling operations.

Another object of the invention is to afford adequate protection to the electronic device against premature application of energy thereto.

Another object of the invention is to ensure that the system will fail safely in the event of short-circuit or failure of component parts.

Other objects and advantages will become apparent from the following description taken in connection with the accompanying drawing which illustrates in a schematic view the improved control system for controlling the flow of fuel to a fuel burning apparatus.

Referring more particularly to the drawing, the main burner 10 is shown as being supplied with fuel from a main fuel pipe 12 under control of the main fuel valve or cock 14 which, if desired, may also incorporate a thermostat device (not shown) responsive to temperature caused by operation of the main burner 10. The main fuel cock 14 also includes a main switch 16 which is operated to closed position when the main fuel cock 14 is opened and is normally opened when the main fuel cock 14 is closed. A pilot burner 18 is located in proximity of the main burner 10 to ignite the fuel flowing therefrom and is supplied with fuel by a conduit 20 under control of the main fuel cock 14. Electric igniting means 22, preferably in the form of a coil of resistance wire, is located in lighting proximity to the pilot burner 18 to ignite the fuel issuing therefrom.

Electrically operable means is provided for controlling the flow of fuel to the main burner 10 and may take the form of an electromagnetic valve 24 normally biased to closed position by gravity, spring means or the like, to prevent the supply of fuel to the main burner 10. The valve 24 has an energizing coil 26 and a relatively movable core 27 operatively associated therewith for causing the valve 24 to open when energy of sufficient value is supplied to the coil 26. As will be apparent, the supply of fuel to the main burner 10 is under control of both the main fuel cock 14 and the valve 24 while the supply of fuel to the pilot burner 18 is under control of the main fuel cock 14 only.

Depending from the core 27 beyond the coil 26 is an operating stem 28 having spaced contact bars 30 and 32 carried thereon. The stem 28 together with its associated contact bars 30 and 32 is adapted to reciprocate upon movement of the core 27 in the opening and closing movements of the valve 24. Such movement of the contact bars 30 and 32 is relative to two fixed contact pairs 34 and 36 and provides switch means for circuits to be described hereinafter. It may be noted that when the coil 26 is deenergized valve 24 closed, contact arm 30 is disengaged from contact pair 34 while contact bar 32 is in engagement with contact pair 36. Alternatively, when the coil 26 is energized and valve 24 is opened, then contact bar 30 is in engagement with contact pair 34 while contact bar 32 is disengaged from contact pair 36.

An electron discharge device 38 of the thyatron type is provided for controlling operation of the valve 24 in conjunction with means to be described hereinafter. The cathode 40 of the electron device 38 is indirectly heated by a heating filament 42 and these elements are housed together with a control grid 44, shield grid 46 and anode 48 within the usual gas-filled envelope 50.

A timing device 52 is provided for delaying the operation of the electromagnetic valve 24 during a predetermined starting period which, in this instance, may be ten seconds. The timing device 52 is of the thermal type and includes a bimetallic strip 54 having a heater 56 in the
form of a coil of wire associated in heating proximity therewith. The bimetallic strip 64 carries a contact 68 and is adapted to warp when heated by the heater 66 to engage contact 58 with a relatively fixed contact 60. The timing device 62 is provided to introduce an appropriate purge period into the system, as will be more apparent hereinafter. The second timing device 62 is also of the thermal type and includes a bimetallic strip 64 having a heater 66 formed of a coil of wire associated in heating proximity therewith. The bimetallic strip 64 is adapted to warp when heated by the heater 66 to disengage a contact 68 carried by the bimetallic strip 64 from a relatively fixed contact 70.

A step-up, step-down transformer 72 controls the energization of the electron discharge device 38 as well as various other elements which are electrically energized. The transformer 72 comprises a line voltage primary 74, a high voltage secondary 78, and low voltage secondaries 76 and 80. The line voltage primary 74 is connected at one end through the main switch 10 to a line wire 79 and at the opposite end to a line wire 81. While any suitable voltage may be employed depending on the voltage of the current source available and the operating characteristics of the electron discharge device 38, the primary winding 74 in this instance is intended to deliver a 110-volt line source of energy and the windings 76, 78 and 80 may be designed to operate at voltages of 250 volts, 6 volts and 4 volts, respectively. As far as the present invention is concerned, the function of the transformer 72 and the connections for supplying energy as described above of the control system can be varied, it being understood that the step-up winding may be omitted if an appropriate electron discharge device is used and connected directly to a suitable primary power source.

As previously indicated, the safety control system to which this invention pertains includes thermal resistance means of a known type which operates in conjunction with cooperating elements to control the flow of fuel to the burner 10 should the pilot burner 18 become extinguished. Thus, the thermal resistance means comprises a variable resistor 82 in the form of a coil of wire of material having normally a relatively low resistance and a positive temperature coefficient of resistance. The resistor 82 is located in proximity of a flame from the pilot burner and is adapted to increase sufficiently in resistance value when heated thereby to perform the required function. It will be apparent that the passageway of electrical energy through the resistor 82 will also cause it to become heated to some extent but it is the heating thereof by the flame of the pilot burner 18 which is primarily responsible for its usefulness in the disclosed system.

A second variable resistor 84 is provided for cooperation with the resistor 82 and is also formed of wire and coil of wire of material having a relatively low resistance and a positive temperature coefficient of resistance. This second resistor 84 is not, however, exposed to the flame of any burner and is adapted to vary its resistance only due to the passage of electrical energy therethrough.

A potential divider 86 cooperates with the resistors 82 and 84 in the operation of the electron discharge device 38. The potential divider 86 consists of the usual resistance means 88 and 90 in series and provided with a tap 92 forming part of a connection between the circuit of the secondary 78 and that of the secondary 76 as will be apparent hereinafter.

A timing circuit of conventional form is provided for producing necessary time-delay for operation of the system. This timing circuit comprises a resistor 88 and a capacitor 90 in parallel and connected to the circuit of the grid 44 of the electron discharge device 38. A second capacitor 92 of suitable size is connected in parallel with the coil 26 of the electromagnetic valve 24 to smooth the current flow to the coil 26 and maintain a relatively uniform current flow thereto. The various elements of the system are completed by the provision of a resistor 100 for adjusting the value of the energy supplied to the igniting means 22.

In the subsequent description of the operation of the system the various circuit connections for the described elements will be outlined together with the cooperation between the various elements to produce the desired results. With the various elements in the positions shown in the drawing and the system inoperative, the fuel supply and 110-volt alternating current supply to the primary 74 of the transformer 72 are turned on simultaneously by operation of the main fuel valve 14. Thus, fuel flows in the conduit 20 to pilot burner 18 and the transformer 72 becomes excited, if the solenoid valve 24 is biased closed, there is no flow of fuel in the main fuel pipe 12 to the main burner 10 at this time.

The six-volt secondary 76 of the transformer 72 being energized there is established a potential across a bridge circuit which comprises the resistance means 88 and 90 as well as a wire 92 individually the four arms thereof. The bridge circuit is connected across the six-volt secondary 76, as follows: upper terminal of secondary 76, wire 102, bridge junction A, resistance means 88, junction B, resistance means 90, junction C, resistance means 84, junction D, wire 103, resistance means 82 and wire 105 back to junction A, it being noted that wire 104 completes the connection of junction C back to the lower terminal of secondary 75.

The input coil of the electron discharge device 38 comprising control grid 44, shield grid 46 and cathode 40 is connected as the detector branch of the aforesaid bridge circuit, as follows: junction B, tap 92, wire 106, cathode 40, control grid 44, wire 108, resistor 94, and wire 110 to junction D. A wire 112 extending from the wire 106 to the shield grid 46 serves to connect this element to the cathode 40.

The lower terminal of the 250-volt secondary 76 is connected to the wire 105 leading to cathode 40 by a wire 114 and the upper terminal of the secondary 76 is connected by a wire 116 to one terminal of the coil 26 of the electromagnetic valve 24, the opposite terminal of which is connected by a wire 118 to the bimetallic strip 54 of the timing device 52. Thus, when the contacts 58 and 60 of this timing device 52 are engaged, a circuit is completed to the anode 48 by a wire 120 extending between this element and contact 60. The cathode 40 becomes heated by the heating filament 42 which is connected to the six-volt secondary 76 by a wire 117 connected to wire 105 and by a wire 119 connected to wire 104.

Meanwhile, the igniting means 22 is energized through a circuit from the lower terminal of the four-volt secondary 90, wire 136, igniting means 22, wire 122, resistor 100, wire 124, bimetallic strip 64, contacts 66, 70, wire 126, contact
5 pair 38, contact bar 32, wire 128, heater coil 10 and wire 120 back to the upper terminal of transformer secondary 80. Thus, the fuel issuing from the pilot burner 18 is ignited and the flame produced thereby serves to heat the variable resistor 82 and cause it to increase in resistance value. Simultaneously, the heater coil 68 is energized and after an appropriate time delay serves to heat the bimetallic strip 54 sufficiently to cause it to warp and engage contact 58 with contact 60. The anode circuit previously traced in thus completed.

The completion of the anode circuit as described does not cause immediate energization of the coil 25 of the electromagnetic valve 24 until there is a flow of full average anode current. The potential established by the secondary 76 across the described bridge circuit is of the opposite polarity to that supplied to the described anode circuit of the electron discharge device 38. The magnitude of this voltage is such that the negative bias on the control grid 44 prevents the device 38 from becoming conductive until this bias voltage is sufficiently reduced to permit such functioning. It may be noted that the bias of the control grid 44 is an alternating voltage that is approximately 180 degrees out of phase with the anode voltage. The magnitude of this grid bias becomes sufficiently reduced by heating of the variable resistor 82 by the flame of the pilot burner 18 which occurs after a predetermined period of operation of this burner.

It will be apparent that in normal operation the electron discharge device 38 becomes conductive on the anode positive half-cycle while the control grid 44 regains control on the anode negative half-cycle. It will furthermore be apparent that the connection of the shield grid 46 and the control grid 44 could be interchanged if desired without affecting the essential operation of the device. Upon the electron discharge device 38 becoming conductive, as described, the output circuit thereof supplies sufficient energy to the coil 25 of the valve 24 to cause the latter to open and admit a continuous supply of fuel from the main fuel pipe 14 to the main burner 18 in which it is ignited by the pilot burner 18. The energy so supplied to the coil 25 is half-wave or pulsating direct current at approximately 110 volts due to the rectifying effects of the electron discharge device 38. As previously mentioned, this current is maintained steady to the smoothing effect of the capacitor 98 connected across the terminals of the coil 26.

When the coil 26 is energized to open the valve 24, the core 27 moves downwardly as viewed in the drawing to reverse the position of the contact bars 30 and 32 shown therein. Thus, the contact pair 36 is opened and consequently the circuit of the igniting means 22 and the heater coil 56 of timing device 52 is deenergized. The bimetal strip 64 thereupon cools and causes disengagement between the contacts 58 and 60, wire 128, contact 38, the electron discharge device 38 being maintained due to engagement of contact bar 30 with contact pair 34 to establish a parallel circuit, as follows: lower terminal of secondary 76, wire 114, cathode 49, anode 46, wire 128, contact 38, the electron discharge device 38, wire 130, coil 26 and wire 116 back to the upper terminal of transformer secondary 76. It is apparent that the establishment of this circuit serves to energize the coil 68 to cause heating of the bimetallic strip 64 of the timing device 62. Consequently, contacts 66 and 70 become disengaged and remain in such position during normal operation of the main burner 18.

The system will remain in the steady state operation described until manually shut-off by operation of the main fuel valve 14 or until the flame at the pilot burner 18 is extinguished. In the latter case, the potential drop across the resistor 82 is decreased as soon as this element starts to cool. The rate of decrease of this potential is augmented by the action of the resistor 84 which is also responsive to temperature changes as described. The bias of the shield grid 46 is finally changed in a negative direction so as to cause the output current of the electron discharge device 38 to decrease sufficiently to cause effective deenergization of the coil 25. The valve 24 thereupon closes to shut off the fuel supply to the main burner 18.

The system does not immediately recycle for a new starting period due to the provision of a purge period to permit unburned fuel from the main burner 18 to flow away before an igniting operation is conducted. Such purge period is provided by the contacts 66, 70 of the timing device 62 which remain open for a period of time that is in proportion to the time that the electromagnetic valve 24 was open but which does not exceed a predetermined period chosen in constructing the device. When the contacts 66, 70 again close due to cooling of the bimetal strip 64, the illuminating means 22 is reenergized and the described starting operation is automatically conducted.

In the event that an electrical power interruption occurs, the flame at the pilot burner 18 does not become extinguished although the coil 26 of the valve 24 is deenergized for the duration of the power failure. Upon resumption of the power supply the system automatically recycles since the thermal resistor 82 has remained heated by the flame from the pilot burner 18.

It will be apparent that the circuit is so arranged that the system fails safely upon failure of the electron discharge device 38 or of the igniting means 22. Moreover, the timing device 52 introduces the required time-delay during the starting period to prevent application of energy to the filament 42 and the anode 46 of the electron discharge device 38 simultaneously, thus increasing the useful life of this component. It will further be observed that the shunt circuit for the contacts 56, 60 of the timing device 52 which is established by operation of the core 27 to engage contact bar 30 with contact pair 34 occurs prior to the time when the contacts 58, 60 are opened. Consequently, no arcing can occur in this operation.

While a preferred embodiment of the invention has been shown and described it is apparent that many other modifications will occur to those skilled in the art. Hence, the invention as described is deemed to be limited only by the scope of the claims appended hereto.

I claim:
1. In a control system for fuel burning apparatus having a source of fuel supply, the utilization of valve means for controlling flow of fuel to be burned, electromagnetic means for operating said valve means between controlling positions, an electron discharge device having the output circuit thereof connected to said electro-
magnetic means for controlling the supply of energy thereto, biasing means for normally applying a negative bias to said device for rendering the same effectively non-conductive, said biasing means including resistance means adapted to be responsive to temperature changes caused by the heat of the burning fuel for varying in resistance value and causing a sufficient reduction in said bias to render the device conductive, a timing device operable for controlling said output circuit, means for rendering said timing device operable for establishing said output circuit after a predetermined period during which said resistance means has time to become responsive, and means operable upon energization of said electromagnetic means for rendering the last said means inoperative while maintaining said electromagnetic means energized under control of said electron discharge device.

2. In a control system for fuel burning apparatus having a source of fuel supply, the combination of valve means for controlling a flow of fuel to be burned, electromagnetic means for operating said valve means between controlling positions, an electron discharge device having the output circuit thereof connected to said electromagnetic means for controlling the supply of energy thereto, biasing means for normally applying a negative bias to said device for rendering the same effectively non-conductive, said biasing means including resistance means adapted to be responsive to temperature changes caused by the heat of the burning fuel for varying in resistance value and causing a sufficient reduction in said bias to render the device conductive, a timing device having contacts operable for completing said output circuit, electrically operable means operatively associated with said timing device for causing operation of said contacts after a predetermined period during which said resistance means has time to become responsive, and switch means operable upon energization of said electromagnetic means for causing deenergization of said electromagnetically operable means while establishing a shunt on said contacts to maintain said electromagnetic means energized under control of said electron discharge device.

3. In a control system for fuel burning apparatus having a source of fuel supply, the combination of valve means for controlling a flow of fuel to be burned, electromagnetic means for operating said valve means between controlling positions, a source of electric energy, an electron discharge device, biasing means for normally applying a negative bias to said device for rendering the same effectively non-conductive, said biasing means including resistance means connected to the source and the input circuit of said device and being responsive to the heat of flame at the pilot burner for varying in resistance value and causing a sufficient reduction in said bias to render the device conductive, a thermal timing device having contacts operable for completing the output circuit of said electron discharge device including the source and said electromagnetic means, a heater for said timing device connected to the source for causing operation of said contacts after a predetermined period during which said resistance means has had time to become responsive, an electric igniter for the apparatus connected in circuit with said heater, and switch means operable upon energization of said electromagnetic means for causing deenergization of said heater and said igniter while establishing a shunt on said contacts to maintain said electromagnetic means energized under control of said electron discharge device.

4. In a control system for fuel burning apparatus having a source of fuel supply, the combination of a valve means for controlling a flow of fuel to be burned, electromagnetic means for operating said valve means between controlling positions, a source of electric energy, an electron discharge device, biasing means for normally applying a negative bias to said device for rendering the same effectively non-conductive, said biasing means including resistance means connected to the source and the input circuit of said device for varying in resistance value and causing a sufficient reduction in said bias to render the device conductive, a thermal timing device having contacts operable for completing the output circuit of said electron discharge device including the source and said electromagnetic means, a heater for said timing device connected to the source for causing operation of said contacts after a predetermined period during which said resistance means has had time to become responsive, and switch means operable upon energization of said electromagnetic means for causing deenergization of said heater while establishing a shunt on said contacts to maintain said electromagnetic means energized under control of said electron discharge device.

5. In a control system for fuel burners having main and pilot burners and a source of fuel supply, the combination of electromagnetic means operable for controlling the flow of fuel to the main burner, a source of electric energy, an electron discharge device, biasing means for normally applying a negative bias to said device for rendering the same effectively non-conductive, said biasing means including resistance means connected to the source and the input circuit of said device and being responsive to the heat of flame at the pilot burner for varying in resistance value and causing a sufficient reduction in said bias to render the device conductive, a thermal timing device having contacts operable for completing the output circuit of said electron discharge device including the source and said electromagnetic means, a heater for said timing device connected to the source for causing operation of said contacts after a predetermined period during which said resistance means has had time to become responsive, an electric igniter for the pilot burner connected in circuit with said heater, and switch means operable upon energization of said electromagnetic means for causing deenergization of said heater and said igniter while establishing a shunt on said contacts to maintain said electromagnetic means energized under control of said electron discharge device, a second thermal timing device having contacts operable for opening said igniter circuit, and a heater for said second device controlled by said switch means for maintaining said igniter deenergized for a predetermined period following deenergization of said electromagnetic means.

6. In a control system for fuel burners having main and pilot burners and a source of fuel supply, the combination of electromagnetic means operable for controlling the flow of fuel to the main burner, a transformer having a plurality of secondary windings, an electron discharge device, connections between one of said windings,
said electromagnetic means and said device constituting the output circuit of said device and controlling the energization of said electromagnetic means, resistance means connected to a grid element of said device constituting with a second said winding the input circuit of said device, said resistance means including flame responsive means adapted upon the presence of a flame at the pilot burner to shift the grid bias sufficiently to cause energization of said electromagnetic means, an electric igniter for the pilot burner connected in circuit with a third said winding, and switch means operable by said electromagnetic means for controlling said igniter circuit, said switch means being adapted to cause energization of said igniter prior to operation of said electromagnetic means to supply fuel to the main burner and to cause deenergization of said igniter upon said operation of said electromagnetic means.

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